PROPOSAL FOR CRPAQS TASK 3.3 ANALYSIS

1. Introduction

Technical & Business Systems, Inc. (T&B Systems) and its teaming partner, Parsons is pleased to submit this proposal to address Task 3.3 which relates to how well existing (CRPAQS Network) measurements characterize various meteorological processes. Our proposal has been prepared in response to, and in accordance with, a Request for Proposal (RFP) issued by the San Joaquin Valleywide Air Pollution Study Agency (Study Agency) and the Air Resources Board.

The team of scientists assembled for this proposed work bring together extensive experience and expertise in both field measurement and data analysis techniques. All were major participants in the CRPAQS Field Measurements phase as well the related projects CCOS, IMS95, and AUSPEX/SJVAQS. T&B Systems has been a major contributor to analyses of IMS95 and AUSPEX/SJVAQS data, and has been selected to provide major input to CCOS analysis efforts. The Parsons' scientists on this analysis team provided quality assurance management to the aforementioned programs. As a consequence, the team is intimately familiar with the measurement techniques, and the air quality and meteorology of the Central Valley and adjacent air basins. Moreover, we have all worked together successfully as a team on past projects in a similar capacity.

2. Background

Smith and Lehrman (1996) examined in detail PM_{10} loading in the SJV using the 1988-93 data base of SJV particulate mass and chemistry. Exceedances of the Federal PM standard were infrequent from February through September. Most exceedances occur from October through January. Watson et al. (1998) defined four conceptual models for high PM loading in the SJV; 1) clear sky-stagnation, 2) stagnation with fog, 3) high-wind fugitive dust (early fall), and 4) low-wind fugitive dust.

In the first scenario, significant contributions to PM come from dry chemistry processes as well as regional and localized dust sources. The meteorology conducive to these conditions occur primarily in the fall, prior to the first significant rainfall. Low wind speeds permit build-up of concentrations from local sources. The second scenario is distinguished from the first by the presence of fog which elevates aqueous chemistry to a major contributing process. Low wind speeds also prevail. High winds (Scenario 3) cause soil erosion and generate dust at multiple sites resulting in extensive transport and dilution. Localized PM loading has been observed from farming activities under low wind speeds and will typically only impact a small area.

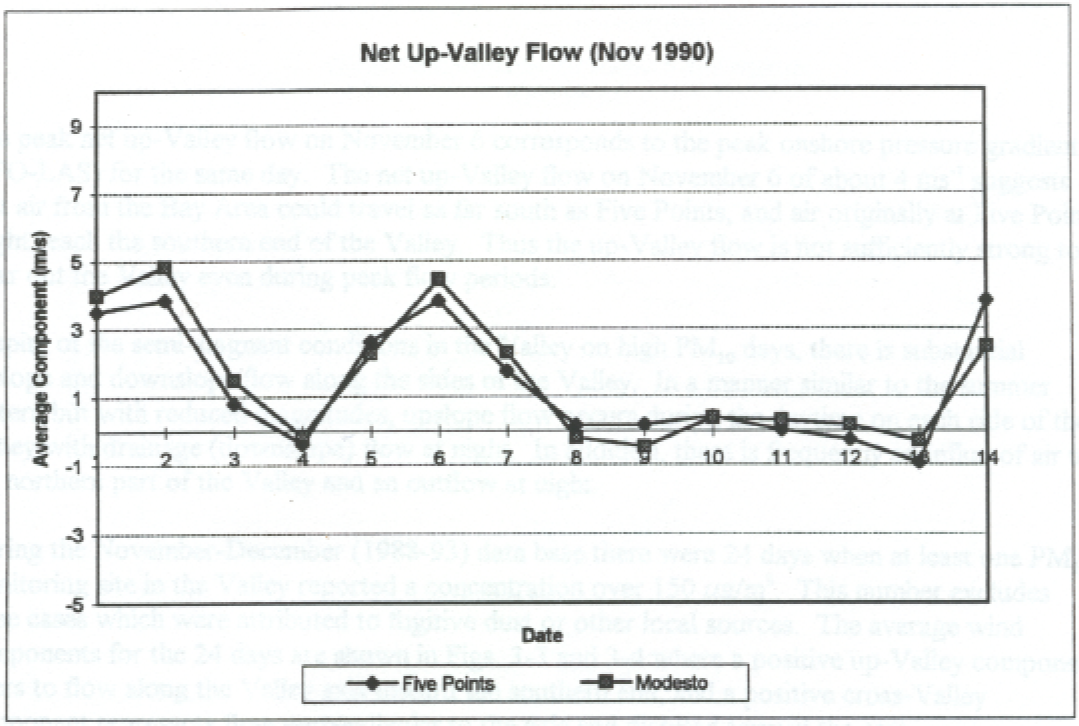
Smith and Lehrman classified the 51 exceedance days in the 1988-93 data base into the Watson's four conceptual models. Twenty-three days or 45 percent of the total were Clear Sky-stagnation, 22 days or 43 percent were Stagnation with Fog, seven days or 14 percent were High Wind Fugitive Dust cases and 6 days or 10 percent were Low Wind Fugitive Dust cases. Clearly, the bulk of PM exceedances occur during the fall and winter under low-wind conditions, thus, deserve to be the focus of attention. Reduced visibilities and moderately high PM levels also occur during the summer months and warrant examination as well.

The 1990 AUSPEX/SJVAQS, a summertime ozone study, provided remarkably good surface and aloft wind coverage within the Valley, most notably in the center along the longitudinal axis. In one or two areas such as the southwest corner, the Westside Operators network provided the data required to describe the extent of cross-valley flows and fluxes between the SCCAB and the SJV in some detail. The CRPAQS/CCOS network was designed to provide similar coverage throughout the annual cycle. In spite of semi-stagnant conditions in the Valley during the fall and winter when there is high PM, there is substantial slope flow along the foothill regions. Transport from the Valley into the Sierra has been documented but there still is a gap in our understanding of the extent of the influence of terrain driven flows from the valley floor into the foothills. This is especially true in the winter when the data are more sparse and slope winds are diminished in strength.

Regional pressure gradients do fluctuate during stable warm temperature episodes and even weak systems occasionally affect intravalley pollutant transport without upsetting the boundary layer. An example is shown in Figure 1 where the daily net-upvalley wind component is plotted for Modesto and Five Points. These sites anchor a transect across the Valley perpendicular to its longitudinal axis. The bottom panel of the figure shows the 850 mb temperature and the north-south and west-east pressure gradient for the same period. The peak net up-valley flow on November 6 corresponds to the peak onshore pressure gradient for the same day. During the period from the 8th through the 13th, net fluxes remained near zero.

A major objective of the CRPAQS field measurements was to provide a wind data set utilizing current measurement techniques and a data density adequate to provide a clearer understanding of transport in the boundary layer during the fall and winter when PM loading in the SJV is greatest. The scope of work defined below is designed to examine the current data set for its temporal and spatial representativeness with regard to research and compliance monitoring needs.

The importance of aqueous chemistry in the formation of secondary aerosol in the SJV has been shown by Smith and Lehrman (1996) and Watson, et al. (1998) as well as other researchers. Therefore, it is important to develop methods to define the areal extent and magnitude of fog/high humidity events. The distribution of fog is not well documented in the Valley. In many cases fog is patchy and it is not possible to say whether a sampled parcel has been subjected to a fog environment or not. Smith and Lehrman attempted to use a systematic procedure to determine the fog environment at a sampling location, and, although imperfect, it allowed classification of high PM days. Our approach as outlined below will start with those procedures and hopefully refine them with CRPAQS data.



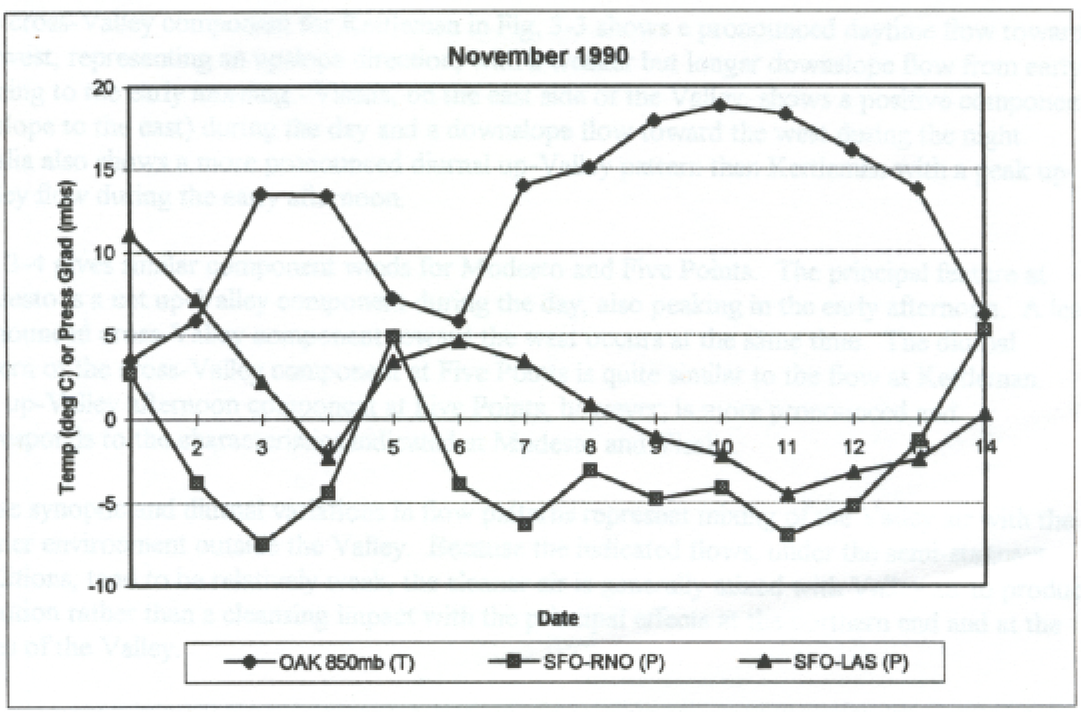


Figure 1. Daily 850 mb Temperature, Pressure Gradients, and Net Up-Valley Flow for November 1-14, 1990 (from Smith and Lehrman, 1996)

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3. Task 3.3 Objectives

The overall objectives of the proposed analyses are to determine:

1. How well the network measurement of winds describe PM transport and dispersion under both light or calm wind conditions.

2. How correctly the network wind measurements describe the Valleywide horizontal flow field including wind gustiness.

3. How adequately the network meteorological measurements describe Valleywide vertical wind shears, vertical thermodynamic gradients (temperature and humidity), and mixing heights.

4. How well the spatial extent, intensity, and frequency of occurrence of fogs are defined by existing meteorological measurements.

4. Technical Approach

This task builds on the analyses performed as part of RFP Task 1.3 whereby the adequacy and validity of measurements are understood, and that understanding is used in this task to assess how well the measurements can describe the requested phenomena. As an example, objective 1 above is to evaluate the existing measurements to describe the transport and dispersion under low wind speed/stagnation conditions. Task 1.3 will have categorized each of the measurements and their ability to adequately measure the low wind speed phenomena. This task will expand upon this measurement ability to assess how well spatially and temporally these measurements can then characterize the transport and dispersion for select cases. The results from this task can feed directly into subsequent tasks such as 5.2 for expanded analyses. Subtasks to be performed will include the following:

Subtask 3.3.1 Transport and Dispersion Under Both Light or Calm Wind Conditions

a) Using key sites that include both the existing measurements and measurements added for the annual program, we will select a subset of the network for assessing how well transport is observed. It is anticipated that these sites will include Visalia (an existing station), Lemoore and Angiola. Angiola provides the most detailed measurements and is key in the overall analysis program. The Lemoore and Visalia sites then form a good triangle of geographic coverage in a region of interest.

b) Appropriate IOP periods will be identified for analysis and data availability for each of the sites verified for each period.

c) Surface and upper air winds will be analyzed for consistency and comparability between the selected sites. While we are not necessarily looking for representativeness of the sites to each other, we will be looking for trends and patterns that make meteorological sense based on our understanding of the flow regimes in the Valley. The goal is to determine if measurements at the existing sites can, in some way, be used to describe the flow within the region encircled by the three sites. This will be performed through plotting and trajectory analyses performed by experienced meteorologists.

d) Surface and upper air winds will be analyzed separately to determine if there are specific levels where the spatial representativeness for transport under the light wind scenario does not work. For example, Carr, et al. (1997) identified significant differences between the 2 and 10-meter winds during stagnation with the 2-meter winds decoupled from the 10-meter winds in the stagnant conditions. However, most transport will occur within the entire surface mixed layer and mixing within the layer will then bring the transported pollutants to the surface. This subtask will evaluate the levels at 10 meters and above to assess the ability to document transport with the measurement network.

Subtask 3.3.2 Measurements of Horizontal Wind Field

a) Using the summer surface and upper air wind network (CCOS and CRPAQS), we will characterize meteorological features previously identified as important transport mechanisms including known corridors into and exiting in the SJV, the nocturnal jet, the Fresno and Bakersfield eddies, and slope flows. We have already examined wind profiler measurements at sites in the Fresno and Sacramento areas as part of a "fast track" analysis of CCOS.

b) The influence of slope flows during periods when synoptic pressure gradients are weak (Subtask 3.3.1) will be examined. The rich data set of continuous light-scatter measurements will be used to evaluate slope flows as ventilating and transport mechanisms.

c) Likewise, the meteorology and nephelometry in Altamont, Pacheco, Tehachapi and Tejon Passes; and Carrizo Plain will be examined during periods with light/calm winds in the Valley.

d) The areal and temporal coverage of the CRPAQS data base will be evaluated.

Subtask 3.3.3 Measurements of Gustiness

a) The surface meteorological sites that reported peak gusts will be compiled, and stratifed by method (e.g., max 3-sec average each hour, max instantaneous reading), by sensor height, etc.

b) Methods to normalize to the extent possible will be determined, and the data processed accordingly.

c) Cumulative frequencies of peak gusts will be developed.

d) Using Satellite network MiniVol filter sampler data, select cases (days) with 1) widespread occurrences of significant crustal component and 2) cases with isolated instances.

e) Examine gustiness and RR903 nephelometer data sets for the select cases. Examine the impact on light scatter.

Subtask 3.3.4 Vertical Thermodynamic and Winds Structure

a) Using the results of the analyses performed in Task 1.3 to determine the usefulness of RASS data for assessing the temperature structure, the existing network of sites will be evaluated for the winter IOP periods to determine if they can adequately represent the vertical temperature structure during stagnation conditions. Data across the existing network and the added stations for CRPAQS will be reviewed for the ability to document the thermodynamic structure. Vertical plots of the data will be reviewed to quickly identify the ability of RASS to "see" low enough to capture the phenomena of interest.

b) If RASS is not adequate, then an assessment of the tower temperature data will be made to assess whether tall tower measurements (such as those at Angiola) are needed to appropriately understand the vertical temperature structure.

c) The lower radar wind profiler data will be evaluated for its adequacy to provide vertical resolution wind structure within the surface-boundary layer. The surface-boundary layer heights will be estimated using RASS data (the data set most readily available on a routine basis) and other sounding information such as the Fresno and Bakersfield rawinsondes. The results of this analysis will determine if the radar data must be supplemented by the high-resolution sodar data (5 meter layers) that is available at a limited number of stations during the periods of stagnation and low inversion heights.

d) The rawinsondes taken at Fresno and Bakersfield together with the Angiola tower measurements will provide detail on the vertical structure of relative humidity. In the absence of measurements, humidity is assumed constant within the surface-boundary layer. The validity of this assumption will be examined in this task.

e) The results of the preceeding analysis will determine if the existing radar/RASS and tower measurements should be supplemented with additional towers and/or sodar measurements.

Subtask 3.3.5 Spatial and Temporal Extent of Fogs

a) The humidity data from the CRPAQS data base will be compiled: including project specific sites, ARB and local district sites, CIMIS, NWS, and RAWS sites; any airport visibility measurements (observer, ASOS); high-resolution satellite imagery; and CALTRANS visibility measurements (if available).

b) RH measured in the Valley network will be summarized for winter IOP days. A threshold RH for indicating the presence of fog will be established (for example 95 percent) and summarized for the network of measurements. Likewise, in collaboration with the other analyses participants, an RH threshold for the onset of significant wet chemistry will be set (for example 65 percent), and occurrences summarized.

c) As the data permits (high-resolution satellite images and visibility measurements), the RH network will be evaluated for its ability to accurately define the spatial and temporal nature of fog occurrences.

Subtask 3.3.6 Meetings and Reports

a) CRPAQS meetings will be attended as appropriate by Robert Baxter and/or Don Lehrman (in Sacramento).
b) Monthly progress reports will be prepared.
c) It is anticipated that the final report will consist of a journal article to be submitted for peer-reviewed publication accompanied by appendices that will not be submitted for publication. Because of the close interrelationship of this task to 1.3, this final report will be integrated into the results of the analyses in that task.
d) A paper will be submitted to a technical conference that describes the findings. Similar to the journal article, these findings will be combined with those results obtained in Task 1.3.

5. Project Management and Key Personnel

T&B Systems and Parsons staff will provide a coordinated effort under the direction of Mr. Don Lehrman. Other key personnel that are committed to this task are Mr. Robert Baxter of Parsons ES, and Mr. William Knuth of T&B Systems.

Mr. Don Lehrman is the President of T&B Systems. Mr. Lehrman's career has focused on understanding boundary layer meteorology, field measurements, and data validation and verification. Since co-founding T&B Systems, Mr. Lehrman has been the Project Manager and/or Principal Investigator for numerous field measurement and analytical programs. These include: the NARSTO-Northeast Rawinsonde/Ozonesonde Field Measurements Program (EPRI), an analysis of the San Joaquin Valley meteorological environment during high PM loading, the design and implementation of a network for monitoring in ozone transport corridors in Southern California, implementation of a